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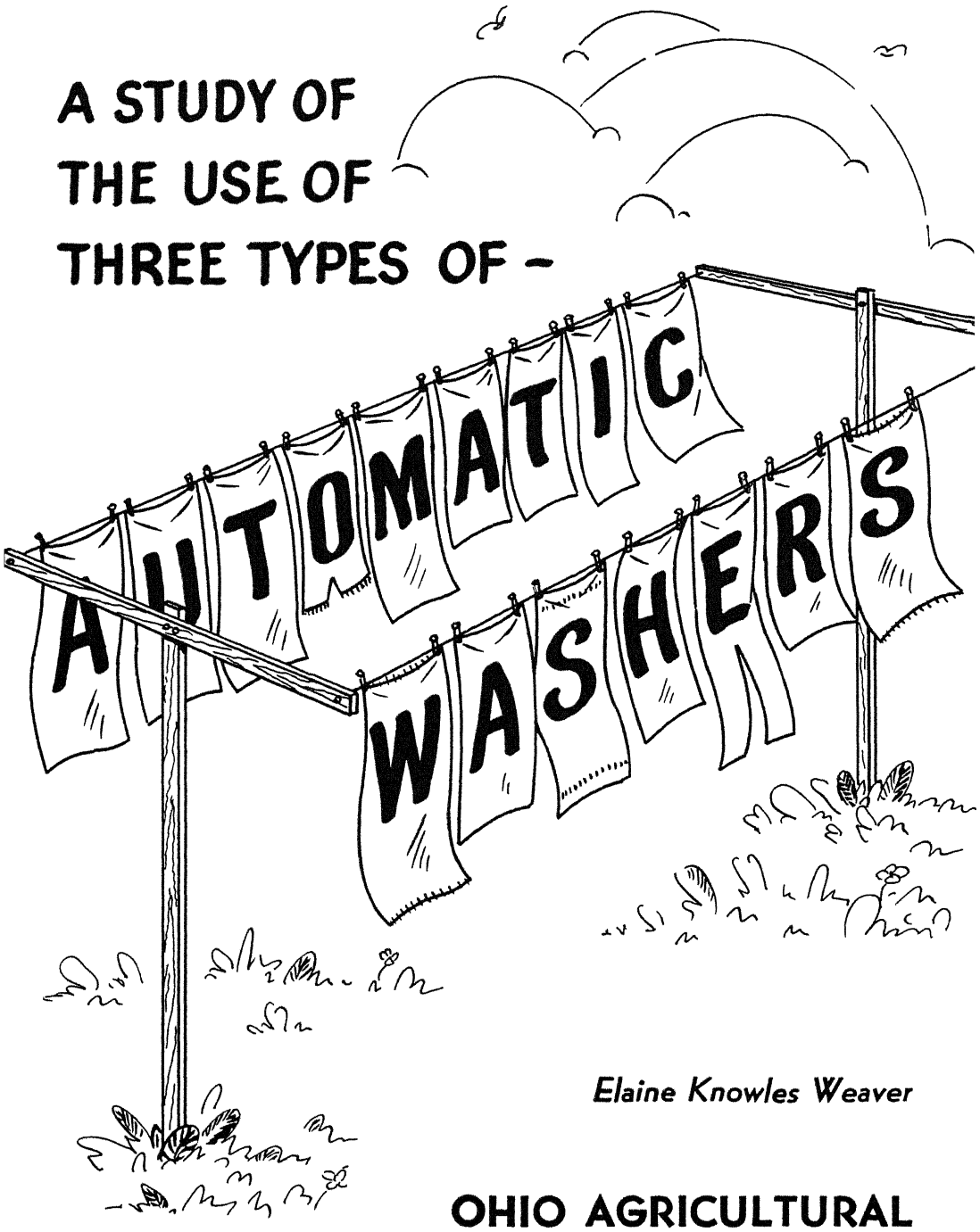
A STUDY OF THE USE OF THREE TYPES OF - AUTOMATIC WASHERS



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A Study of the Use of Three Types of AUTOMATIC WASHERS

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SUMMARY

This study of different types of automatic washers was based on the questions most frequently received from prospective buyers and complaints from users who were experiencing washability problems. To date no information or directives, beyond a few brief magazine articles, have been published which will aid these inquirers in making their selection of a washer or solving difficult problems. After the installation demonstration, users have to rely mainly upon direction books accompanying the washers which, with few exceptions, have been inadequate.

During the 2-year period of this study over 20,000 pounds of soiled clothes were contributed by 32 different families and used for standardized and practical tests.

The washings ranged from 10 to 45.9 pounds with an average of 25.6 pounds; and from 20 to 129 items, with an average of 66.3 items per washing. The type and amount of soil varied widely and offered most of the known washability problems.

Types of automatic washers studied included one pulsator, two cylinders, and two agitators. Because women are acquainted with the conventional wringer-type washer and know what to expect in performance, a good, well-known model was used as a control for comparison with the performance of the automatics.

Columbus city water (68 p.p.m. hardness) heated at the university heating plant was used for all washing tests. A low sudsing built synthetic detergent containing a non-ionic-type wetting agent, water softening compound and other moderately alkaline materials, (10.2 pH) was used in quantity to give a 0.3 percent wash solution for each washer.

Standardized tests for performance included standard soil, whiteness retention, tensile strength, and shrinkage. Test specimens were included as a part of eight pound loads wth mixed white soiled garments. The

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test loads consisted of two sheets, pillowslips, bath and tea towels, table linen, and/or undergarments. All test loads were washed for 10 minutes and beyond that were allowed to proceed with the regular machine cycle.

From the results of the standardized test procedures it was found that:

The soil removal ability of the five washers studied was comparable and that no one type was greatly superior to the other. The control washer (conventional) removed only slightly more soil from 100 test samples than 3 of the automatic washers.

The agitator 3B had the lowest percentage of soil removal but this may be contributed in part to the fact that the maximum water temperature delivered by the washer was 130° which was believed too low to affect the fat and oil content of the soil samples.

It must also be noted that while the soil removal factor was slightly higher in the control washer, the wash water was changed with each load of soiled clothes as would be done in the automatic washers. In homes the general practice is to wash two, three or more loads through the same water. Soil removal tests were not made under this latter condition but it could hardly be expected that soil could be removed as readily in cool, soiled wash water as in the first load of clean, hot water.

It is also questionable that the use of standard soil samples is a completely adequate means for testing soil removal ability. The general appearance of some of the clothes washed in machines which rated higher in soil removal from soil swatches was not as satisfactory as those from the washers rating lower. This was particularly true between the two cylinder-type washers.

The soil removal was slightly but progressively higher as the water temperatures were increased. Grease balls appeared less frequently when temperatures were higher. Tests were not made in water exceeding 149° F. since that temperature in the home would rarely be exceeded.

Whiteness retention was highest in the pulsator washer (98.0 percent) with the control (97.0 percent) and cylinder 2B (96.5 percent) in close range. The pulsator and cylinder 2B included two deep rinses in the cycle. The agitator washers having only one deep rinse plus a flush or spray had slightly lower whiteness retention. Cylinder 2A which also had two

deep rinses had the lowest whiteness retention (92.2 percent.) From general observation of this washer it was believed that the rinsing was not as adequate as it should have been. When using sudsing detergents (soap or synthetic) it frequently seemed necessary to re-rinse, particularly with heavy or thick items.

There was no relationship between water retention and whiteness retention.

The changes in tensile strength varied so greatly that the results cannot be conclusive but it appeared that the washers having mechanical agitation showed slightly greater wear on the test materials than did the cylinder types particularly on the warp direction threads.

It was obvious that the machines had no effect on the shrinkage of cotton tea toweling materials used for testing. The major portion of the shrinkage took place in the first washing and increased not more than 2 to 3 percent during the following 49 washings.

Suitable loading was important in all washers. Loads composed of part large items such as two sheets and smaller items including pillow slips, towels, shirts, undergarments and the like made for well balanced loads. Most regular weekly washings included at least two such loads with one or two additional loads of garments and small items.

Loading was more easily accomplished with the top opening washers than with the cylinder types. Likewise, the agitator and pulsator washers were more easily controlled and more suitable for the washing of wool blankets and clothing. Cylinder types, however, were more simple to operate when washing such items as heavy bedspreads, quilts, shag rugs, pillows, slip covers and similar items.

Washers with a high spinning action (Washer 1, 1130; 3B, 1140 R.P.M.) removed approximately 50 percent more water than other washers used leaving the clothes with about a 50 percent moisture content. Low moisture retention means less weight to carry and handle on the part of the worker, as well as less time required and lower operation costs when an automatic clothes dryer is used.

Some of the manufacturers rated their washers for nine pound loads. Eight pounds or less, depending upon the load content, gave more favorable results.

A suitable detergent in regulated amounts was important in the performance of all machines. Use of a synthetic detergent prevented soap scum and curd formation on clothes and tubs and also eliminated clogging of drainage problems frequently reported by inquirers using soaps.

The low sudsing type of synthetic detergent proved particularly satisfactory in the pulsator and cylinder types where the sudsing variety, when used in sufficient amounts, buffered the loads preventing adequate soil removal, and caused suds locks or overflow.

While a 0.3 percent concentration of the detergent was used for test loads of light or moderate soil, additional amounts were needed for heavy and greasy soil. Otherwise, grease balls frequently occurred and soil was not removed.

Bleaching and other washing aids were seldom necessary except for stains and extra heavy soil.

Washing results were improved when families changed linens and clothing more frequently and items were less soiled. This practice did not necessarily increase the number of loads to be washed since at least four separate loads were usually necessary to take care of the types of items and soil for each family.

Each washer was given an equivalent of from 2 to 10 years use in the home. Little care and servicing were necessary for any of the washers. Frequent cleaning of drain traps being the main item. No deterioration of tubs or washer mechanism was noted.

Conclusions Concerning the Use of Automatic Washers

While automatic washers contribute greatly in reducing the time and effort required for home laundering they will not perform miracles. None of the automatic washers studied were superior in performance to a good, properly handled, conventional washer. No one type or brand of washer was dramatically superior to another in performance. Each had advantages and disadvantages in use.

Each of the five automatic washers studied was completely satisfactory in performance providing that: (1) The machine was properly loaded with items suitably combined as to soil and color fastness. (2) There was a sufficient hot water supply of at least 135° to 140° F. (3) A suitable detergent was used and proportioned according to the nature of the soil.

Stains, soil streaked shirt collars, and the like need pretreatment before washing in an automatic as well as any other type of washer.

While this was not a detergent study the use of various types of detergents, both soaps and synthetics, with a great many loads of clothes in the different washers indicated that synthetic detergents are superior for automatic washers. They eliminated all possibilities of soap curd and scum formation on clothes and tubs. Their use reduced the graying and yellowing already existing in clothes contributed by cooperating families. No service problems from clogged hoses and drains were experienced during the study. Thus it is believed that their use will

eliminate some service problems. The low sudsing variety detergent was particularly effective in the pulsator and cylinder-type washers where suds buffered the washing action and caused suds locks or overflowed the washers. Synthetic detergents containing water-softening compounds would be effective in rural Ohio homes having a hard water supply.

Water supply and pressure need consideration before installing an automatic washer in a rural home. The water requirements of the washers ranged from a total of 26 to 52 gallons per load with minimum pressures of from 15 to 25 pounds. Only one washer was designed to reuse the wash water, if necessary.

Whether an automatic washer will use more water than has previously been used with a conventional washer will depend upon existing washing practices in the home. An average of 4 loads weekly would require from 84 to 208 gallons, depending upon the type of automatic washer. If the homemaker has made a practice of changing wash and rinse waters at least once with the conventional washer and tubs she has probably used from 90 to 100 gallons.

A sufficient hot water supply is important in the performance of the automatic washer. The number of gallons of hot water used by the various washers ranged from 16 to 35 gallons (Since the rinse waters are tempered to 100° F. the amount might be slightly higher in winter when the supply was extra cold). A 30 gallon hot water heater could supply sufficient hot water for only 2 loads in the lower capacity and 1 load in the higher capacity machine without waiting for water to reheat. If the user is willing to change practices and wash 1 or 2 loads on different days during the week, a 30 gallon water heater might suffice. If, however, she insists upon washing all loads in sequence on the same day at least a 50 to 75 gallon hot water tank will be needed to provide enough hot water to insure good performance.

The motors draw heavily on electric current for a few seconds as the washer's tub starts into the spinning action. It is advisable to have the washer on a separate circuit to eliminate strain on the motor and mechanical parts of the washer.

Flexible dial control is important since it is sometimes desirable to change or repeat certain processes such as in the laundering of blankets. Three brands now on the market but not used in this study have restricted dials which cannot be manually operated.

Washers rated for 9 pound loads perform better if load is limited to 7½ to 8 pounds.

Washers which have two deep rinses tended to keep clothes whiter than those having one deep rinse and sprays.

Clothes washed in the machines having high-speed centrifugal water extraction (1130-1140 R.P.M.) dry more quickly than in those with a low speed spin. This is an important factor in the use and cost of operation of an automatic dryer and in handling and carrying clothes to the drying area.

The wear on fabrics appeared to be slightly higher in the agitator type washers but there was no evidence that spinning speed affected wear.

PURPOSE OF RESEARCH

The weekly washing has been a major task in most homes for generations. Studies have shown that it has been considered the most tiring of all of the household activities.[2] It is not only a strenuous task but is done in addition to all of the daily routine of work in the home.

Until recent years, little thought has been given to the planning of a laundry area in homes. Washing has been confined to basements, wash sheds, back porches, or the kitchen. Conventional washers and laundering tubs take up considerable space. The operator had to be on hand during most of the washing period to see clothes through the washing, rinsing, water extraction and other steps in the process.

About 1935 the first automatic home washer was introduced on the market. Only three manufacturing companies actually had models on the market and in homes before 1941. Now, several times that many are producing machines. Because of their recent development little research investigation has been done except by the manufacturers and testing agencies, and general information has not been made available to the public.

An *automatic washer* may be defined as a machine, which, set into operation by the user, will complete the water filling, washing, rinsing, and water extraction sequence, and then stop without further attention.

It is because of the time and labor saving features that automatic washers have received such widespread interest and acceptance. In 1949, automatic washer sales accounted for approximately 10 percent of the 3,065,000 washer sales for that year. As yet, the price of this type of washer, ranging from $190 to $365, is too high for many families. Installation requirements of running hot and cold water with a given pressure have ruled out its use in some homes. Nevertheless, as washers are being replaced and new homes are being established it can be predicted that the percentage of automatic washer sales will increase. As

[2]Eleanor Elaine Knowles, "The Most Tiring Household Tasks as Reported by 582 Homemakers," unpublished Master's Thesis, New York: Cornell University, 1937. 102 pp.

production of the appliance and competition increase it is probable that the costs will decrease. At the beginning of 1950, some manufacturers reduced prices as much as 12 percent.

During 1947-50 several thousand telephone calls and letters from prospective buyers of automatic washers were received by the research investigators of the Ohio Agricultural Experiment Station and The School of Home Economics asking such questions as: "Should I buy an automatic washer?", "What type should I buy?", "Will it wash my clothes as clean as my old washer (conventional)?", and "Will it be 'hard' on the clothes?" Adequate information to answer these questions was not available.

Still other questions and complaints came from users who were not satisfied with the operation of their washers. Among these were "I can't get my clothes clean," "There are large grease balls and lint deposits on my garments. How can I get rid of them?", "The machine tears my clothes," "The clothes are so twisted I can hardly get them out of the machine," "The machine won't fill right," and "I run out of hot water before the washing is done."

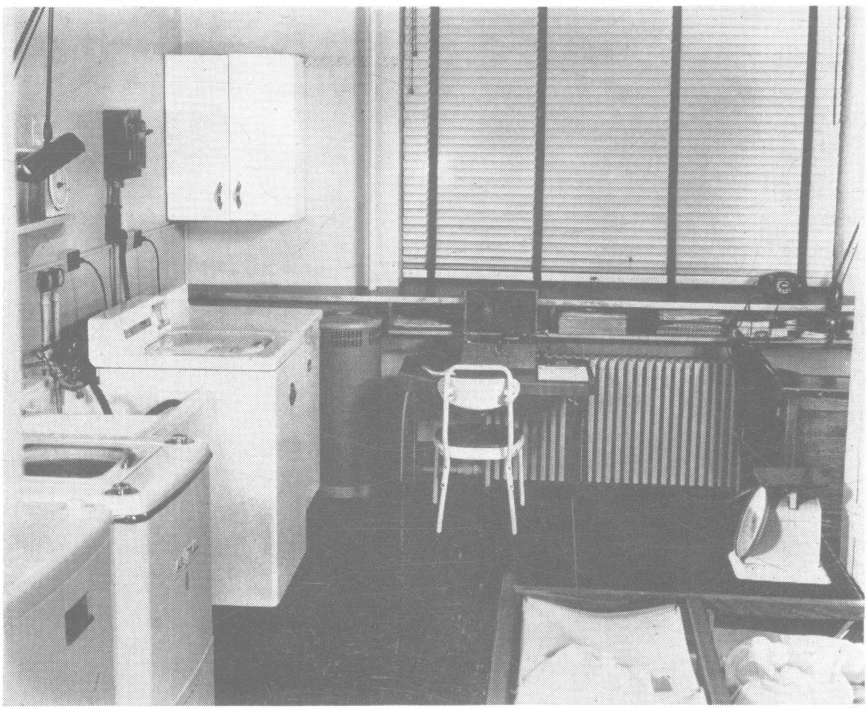


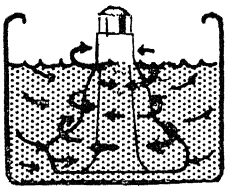
Fig. 1.—Research laboratory at The School of Home Economics at The Ohio State University, Columbus, Ohio, where over 20,000 pounds of family washings were done during the period of this study.

In order to adequately answer these many requests for information a research study on the various types of automatic washers was carried on over a period of two years, 1948-49. During this time over 20,000 pounds of weekly washings, contributed by cooperating families, were washed in the laboratory and various tests, both scientific and practical, were made. (Fig. 1).

The purpose of this report is to give prospective buyers and users the benefits of the experiences and findings of the investigators during this intensive study.

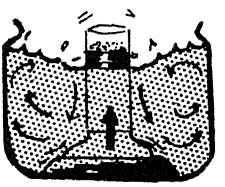
Types of Automatic Washers on the Market

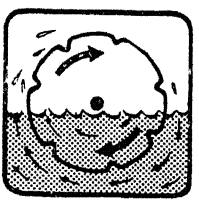
While at the present time fourteen manufacturers have one to four different models of automatic washers on the market, all have one of four types of washing principles. These types are:



1. *Oscillating Agitator*: An agitator mechanism equipped with blades or fins, oscillates back and forth on a central post to create motion of the soiled clothes through the water.

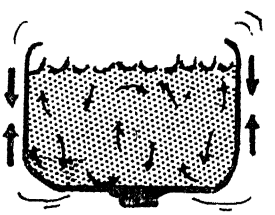
2. *Pulsator Agitator*: An agitator with rubber fins at the top and skirt type bottom operates in an up-and-down motion. This action circulates currents of water from top to bottom of the tub forcing it repeatedly through the clothes as they are kept in action. Cleansing depends mainly upon the water action.





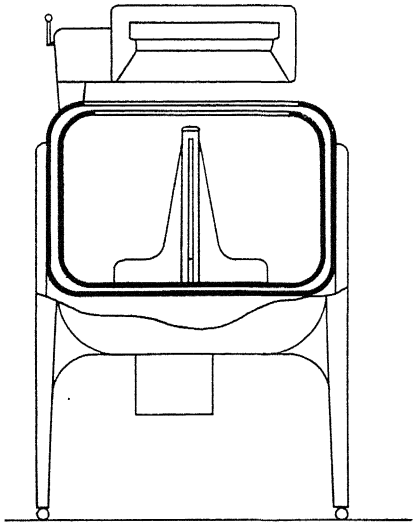
3. *Cylinder or Tumbler*: A perforated cylinder tub, having ledges or projections on the inside, revolves on either a horizontal or an inclined axis within an outer tub containing wash water. As the cylinder revolves clothes are raised on ledges of the smooth projections and drop back into the water. This process creates motion of both clothes and water giving a cleansing action.

4. *Agitated tub:* A bouncing or tossing of the inner tub creates a motion of the water in an up-and-down direction in a manner similar to a hand shaker. This action sets clothes in motion against the swirled sides of the interior of the tub and forces water through them.

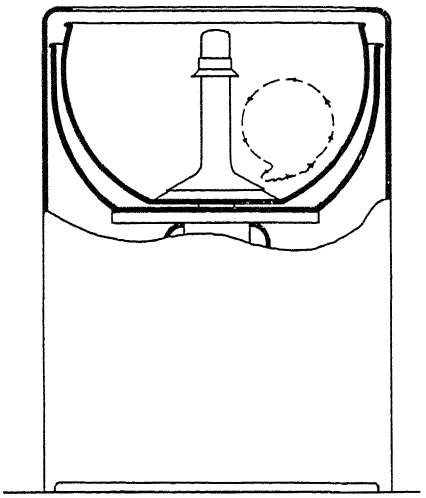


MACHINES USED IN WASHER SURVEY

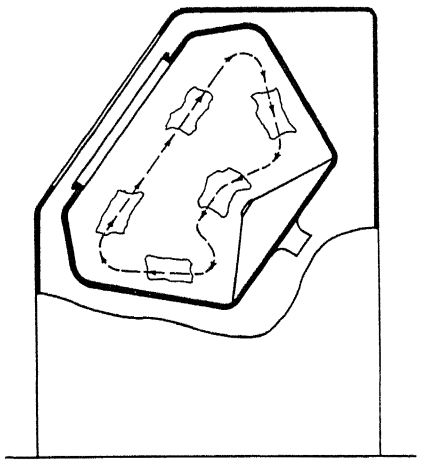
(Figures 2, 3, 4 and 5)



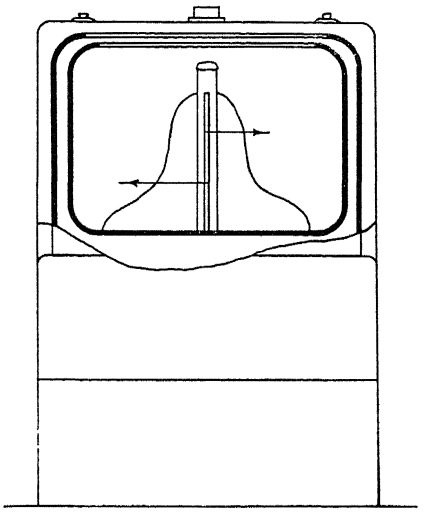
CONVENTIONAL WASHER



PULSATOR TYPE AUTOMATIC WASHER



CYLINDER TYPE AUTOMATIC WASHER



AGITATOR TYPE AUTOMATIC WASHER

TABLE 1.—Features of the Washers Used for Test Purposes as Indicated by the Manufacturers, 1948

Features	1	2		3		Control (Conventional)
	Pulsator type	Cylinder type		Agitator type		
		2A	2B	3A	3B	
Wash-Rinse-Dry Methods						
Washing method	Pulsator	Cylinder	Cylinder	Agitator	Agitator	Agitator
Washing period (maximum)	10 min.	14½ min.	19 min.	15 min.	20 min.	10 min.
Automatic cycle length	29½ min.	49½ min.	35 min.	36 min.	50½ min.	—
Number deep rinses	2	2	2	1	1	2
Number spray or flush rinses	—	2	1	6	1	—
Speed of wash and rinse action	330	59 RPM	60 RPM	60 RPM	60 RPM	—
Hot water used—gallons	18	17	16	20	35	30
Total water used—gallons	30	32.4	26	37.5	52	51
Spinning speed RPM	1130	525	500	650	1140	Wringer
Presoak	no	13½ min.	no	no	yes	—
Tub capacity—pounds	8	9	9	9	9	8
Tub capacity—gallons	11	9	9	17	17	17
Convenience and Safety						
Completely automatic	yes	yes	yes	yes	yes	—
Flexible control	yes	yes	yes	yes	yes	—
Concealed ground wire	yes	no	no	no	no	no
Soap adding method	under water	auto. dis.	surface	surface	dissolver	—
Required bolting to floor	no	no	no	yes	no	—
Automatic spin stop—door open	yes	no	no	no	no	—
Automatic spin stop in unbalanced load	yes	no	yes	no	no	—
Automatic motor protector	yes	no	yes	no	yes	—
Method of loading	top	side	angle	top	top	top

TABLE 1.—Features of the Washers Used for Test Purposes as Indicated by the Manufacturers, 1948—Cont'd.

Features	1	2		3		Control (Conventional)
	Pulsator type	Cylinder type		Agitator type		
		2A	2B	3A	3B	
Convenience and Safety—(Cont'd.)						
Access to tub during cycle	yes	no	yes	yes	yes	—
Single dial control	yes	no	yes	yes	no	—
Mechanical and Construction						
Complete porcelain finish—exterior	yes	no	no	no	no	no
Complete porcelain finish—interior	yes	yes	yes	yes	yes	aluminum
Porcelain spin basket or tub	yes	yes	yes	yes	yes	—
Number of motors—exc. timer	1	1	1	1	3	1
HP mechanism motor	⅓	⅓	⅓	¼	⅓	¼
Type of drive	direct	pulley	pulley	pulley	direct	pulley
Clog proof pump	yes	no	yes	yes	no	—
Drain valves	no	yes	yes	yes	yes	—
Float valves	no	yes	yes	yes	yes	—
Pressure oiling	yes	no	no	no	yes	—
Electric timer	yes	yes	yes	yes	yes	—
Minimum recommended water pressure	25#	20#	20#	15#	20#	—
Height closed (inches)	36¾	36	36	35½	36	—
Width (inches)	25	28¾	31	24	27	—
Depth (inches)	25	24¼	27¼	25½	27	—
Weight crated (pounds)	302	330	311	195	285	—
Additional special features		automatic detergent dispenser		suds return	retained rinse water	aluminum tub

Experimental Procedures Used for the Study

In a survey of literature, no information could be found on methods of study or test procedures for automatic washers. The only available source of information dealing with standardized procedures was a manual issued by the American Laundry Equipment Manufacturers Association to their members. This manual was made available for use but procedures, being confidential, will not be quoted in this report.

Certain of the procedures and methods of study employed by testing laboratories of Association members could not be used in this study because of costs and lack of certain facilities. Where possibile they were duplicated.

Since it was not possible to study all different models available, five representative machines of well-known manufacturers were chosen. Two models were of the agitator type; two of the cylinder type; and one of the pulsator type (only one of its type on the market). At the time this study was in progress the agitated or bouncing-tub type was not yet available.

To rate the performance of a washer, members of the Home Laundry Equipment Manufacturers Association use a specially designed washer with an oversized agitator for comparison. For this study, however, a well known ordinary wringer-type washer (conventional) was used to compare with the automatic washers. It was believed that the results would help to answer the frequently asked question, "Will the 'automatic' do as good a job as my old wringer washer?" All of the tests employed for the automatic washers were duplicated in this conventional washer.

Features of the washers used are listed in Table 1.

Standard Testing Procedures

Test 1. *Standard Soil Tests:*

Ordinary soil found in clothing and household items varies so greatly in type and degree that artificial means must be employed to standardize tests. Ordinary grease, oil, and carbon materials offer greatest resistance in laundering. These materials are used in the artificial soil. Agreement has not been reached among various testing laboratories as to a standardized formula and treatment for standard soiling of test materials. Because of the high cost of standard soil material and quantities needed, the material was prepared in our own laboratory.

Since the appearance of sheets and pillow cases is known to be the homemakers measuring stick for acceptable washing, a good grade of cotton sheeting was used for the soil material rather than coarser Indian

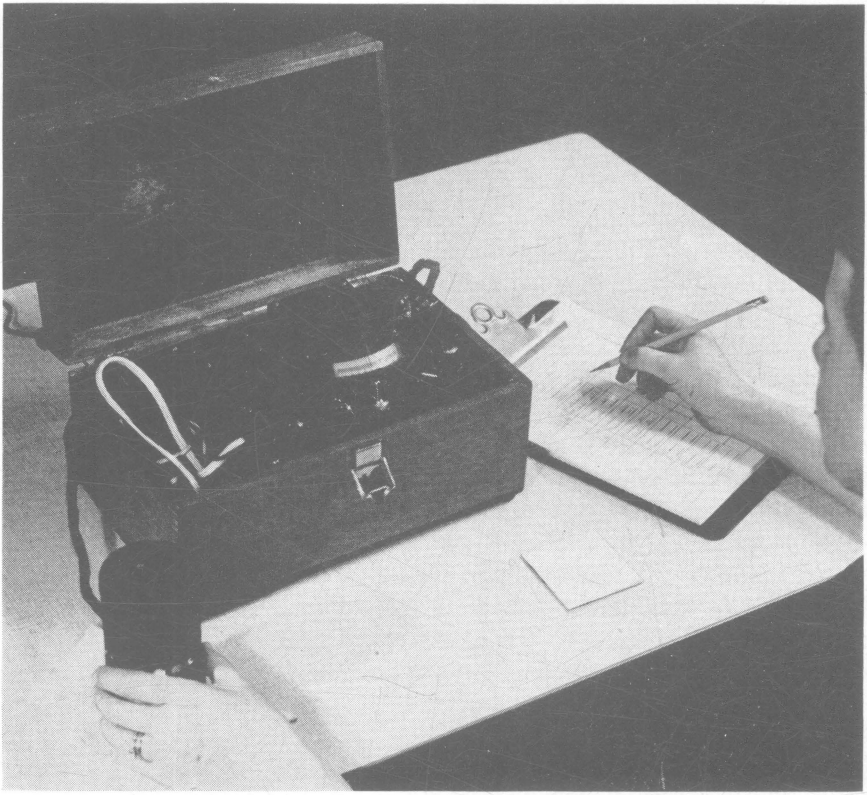


Fig. 6.—The Photovolt Meter used to measure the light reflectory of the standard soil materials before soiling, after soiling and after washing. It was also used to measure the whiteness retention of materials.

Head muslin which is generally used by testing laboratories. Soil removal from the sheeting material was considered more nearly approximate that under home conditions.

The material had a light reflectancy of 80 ($\pm$ 1.5) as compared against the 70 percent calibration plate of the Photovolt meter as a standard (Fig. 6).

Material was cut into nine-inch squares and desized by soaking in a 4 percent solution of Rhozyne D X for one hour. Squares were stirred often to shake out folds and allow complete penetration. At the end of the soaking period, the squares were rinsed through three different tepid waters and hung over a drying rack.

For soiling, the formula previously used in studies at the Pennsylvania State College and Purdue University was employed:

3 liters carbon tetrachloride
8 grams Norite
150 grams Crisco
150 C. C. S.A.E. Motor Oil #30

All ingredients except Norite were warmed separately in sealed containers to about 100° F. by placing in a water bath. Thus carbon tetrachloride and fats blended easily and evenly. Two solutions were made up for each soiling process; one without Norite for a clear rinse prior to soiling.

The desized samples were allowed to tumble for five minutes in a preheated automatic clothes dryer before being placed in the soiling solution. This process removed any moisture which the swatches might have absorbed from the air. As soon as samples were removed from the dryer, they were dropped into the clear carbon tetrachloride and fat solution which was in a small tumbler machine (Fig. 7), and tumbled for five minutes. Twelve samples were processed at one time. At the end of this period the contents were poured from the tumbler, the soil solution was transferred to the tumbler and samples were immediately put into the soil solution. The samples were agitated for a total running

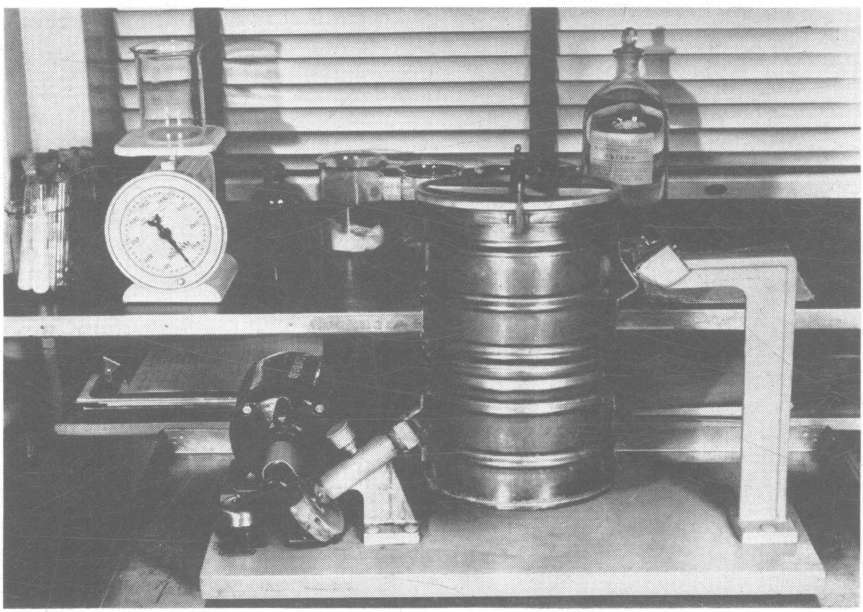


Fig. 7.—Small tumbling machine used in the preparation of the standard soil materials.

time of 30 minutes. Twice during the process the machine was stopped and the swatches pulled apart to assure even soiling. At the end of the agitation period samples were removed, rinsed in the clear solution and hung on racks to dry.

After drying, excess and loosely held surface soil was removed by a short washing treatment. For this treatment two gallons of water of about 100° F. with two tablespoons of a low sudsing detergent were used and samples were rinsed up and down for about one minute each. They were then rinsed in two clear waters of the same temperature. The samples were washed to give a light reflectancy of 20 percent ($\pm$ 4.0) after the samples were dried.

No samples were used in less than 14 days after soiling and were kept no longer than 60 days.

Reading of the Samples:

Each soiled sample was read on 12 different spots by a Photovolt Meter calibrated with a .20 percent reflectancy plate with a green light (Fig. 6). The average figure was used to denote the reflectancy of the sample. By folding each sample lengthwise once and then into thirds, approximately the same area could be read each time the sample was studied.

The formula used for the calculation was:

$$\text{Percent of soil removal} = \frac{\text{original soiled reading—final reading} \times 100}{\text{original soiled reading—original white reading (unsoiled)}}$$

Placement of Soil Samples for Washing:

Four samples were pinned to each of two one-yard square white muslin sheeting swatches of the same material in positions A, B, C and D. (Fig. 8).

The two squares were added to the test loads. Square 1 at the bottom of the load, Square 2 on top. One sample from a given position on each square was removed after each washing and replaced by a fresh sample. Each of the other three samples was read after 10 washings and returned to the square for the complete test of 50 washings.

Test 2. *Whiteness Retention:*

Graying and yellowing of white items is a problem of general concern to women so that whiteness retention was given consideration in studying the rinsing ability of the machines. It was recognized that the detergency factor was important with soiled clothes but the graying of new white swatches would be due to the amount of retention of the suspended soil in the wash water and the degree to which it was removed through rinsing.

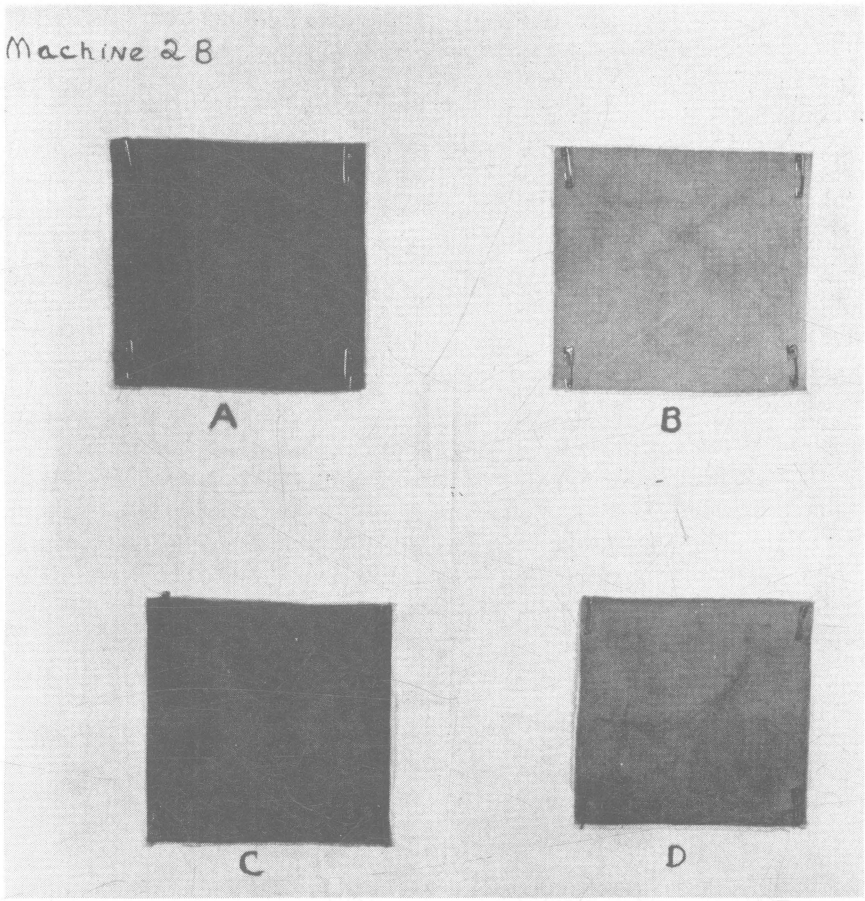


Fig. 8.—The arrangement of the standard soil samples on white muslin sheeting swatches. Two swatches were placed in each test load during fifty different washing periods.

For this test, two one-yard square swatches of white muslin sheeting with light reflectancy of 80 ($\pm$ 1.5) were washed in the washers with the 50 soiled test loads of regular family washings.

After the fiftieth washing the squares were each read on the Photovolt Meter at 24 different spots to determine the loss of whiteness and the degree of graying from soil retention.

Test 3. *Tensile Strength Loss:*

"Will the automatic be 'harder' on my clothes than my old washer?" was one of the most frequent questions asked by prospective buyers of automatic washers.

In order to determine if or to what extent the mechanical action in any of the machines affected the strength of the fabrics, breaking strength tests were made.

For these tests muslin sheeting was used. This fabric had a thread count of 60 by 74 per square inch. Four one-yard squares were added to each machine load and were washed 50 times with the soiled clothes (washing period, 10 minutes), and air dried on racks.

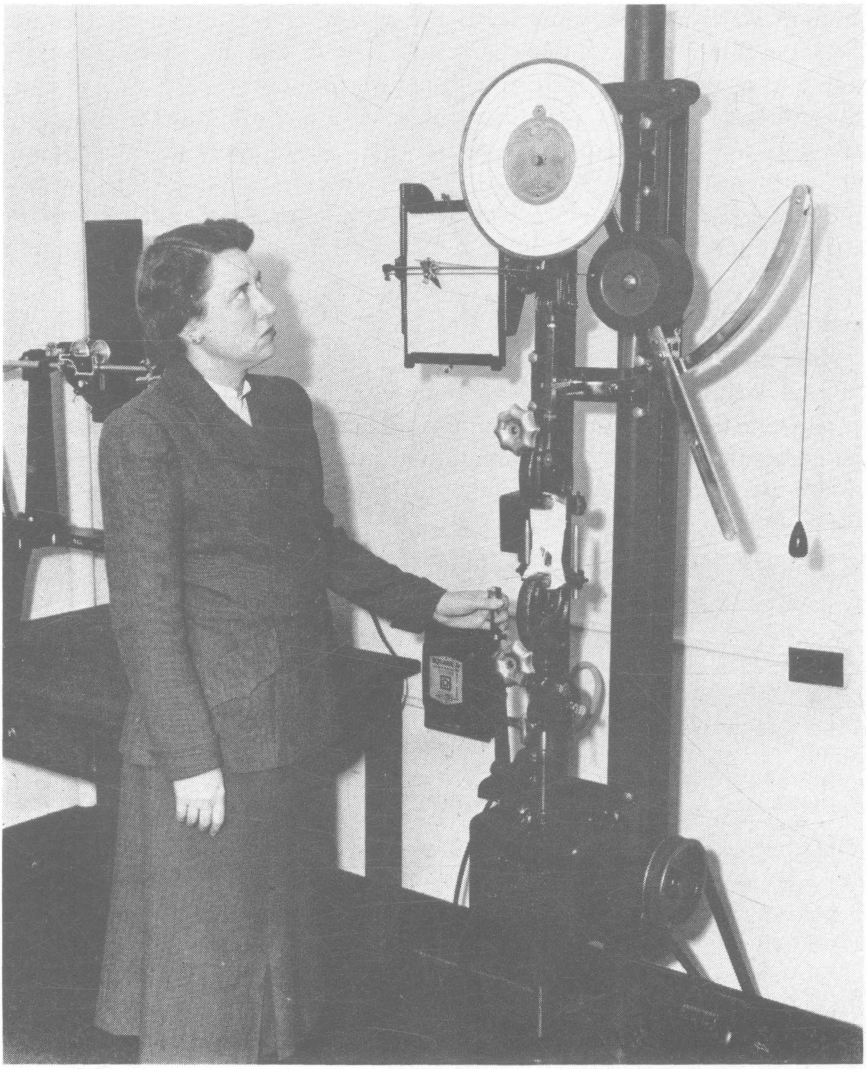


Fig. 9.—This is Scott Tensile Tester used to check loss in tensile strength after laundering.

The tests were made according to American Society for Testing Materials (October, 1947, pp. 87) using the Grab Method. Test specimens four inches in width and six inches in length were used. Tests were made on new material, and after twenty-five and fifty washings, two sets of five specimens were cut from each square, one set for warp breaking strength having the longer dimension parallel to the warp yarns, and the other set for filling breaking strength, having the longer dimension parallel to the filling yarns. No two specimens for warp breaking strength contained the same warp yarns or for filling breaking strength, the same filling yarns. All specimens were taken no closer than six inches from the selvage or torn edges of the swatch.

All test specimens were placed in a controlled room with 65 percent humidity for 24 hours before testing, which was done in the same room. A Scott tensile tester was used. The average of the results of five individual tests on the warp will be reported as warp breaking strength and those on the filling as filling breaking strength at pounds per square inch.

Test 4. *Shrinkage Tests:*

Cotton tea toweling was used for the tests to check effects of washer type on shrinkage. Twenty-four inch lengths were cut and each length was hemmed to prevent raveling. A 12 inch square was marked off in the center and black linen thread was stitched at the corners of the square, two inches in each direction, to establish landmarks for measurements. (Fig. 10).

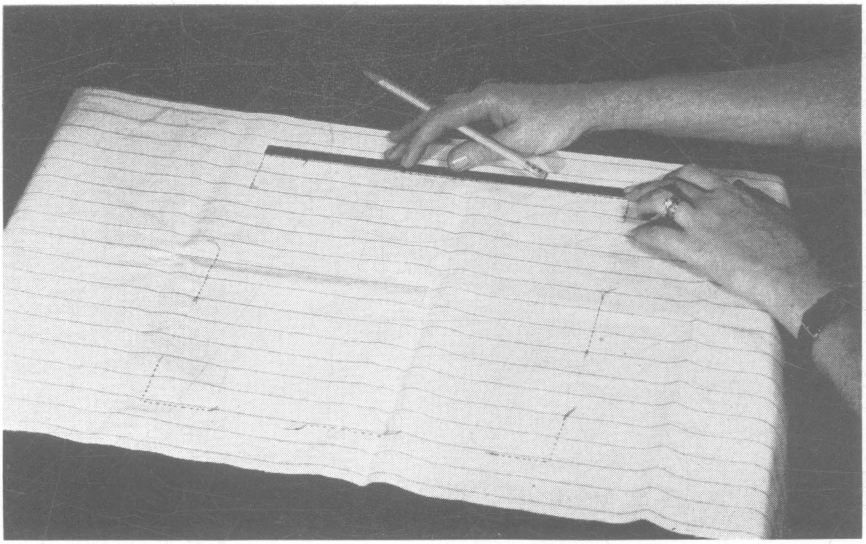


Fig. 10.—Landmarks used on tea toweling for shrinkage measurements.

Three lengths were used for each machine and were washed through 50 tests with soiled clothes. Following washing and rinsing periods, swatches were air dried after being smoothed out across a drying rack.

Measurements were made after the first, tenth, twenty-fifth and fiftieth washings. Before measuring, samples were dampened with water and allowed to stand for five minutes, then pressed with a hand iron, care being taken to avoid any strain on the cloth. Following pressing they were allowed to cool before being measured.

Pressed samples were laid out without tension on a flat surface. Distances marked off were measured and shrinkage in the warp and filling directions were calculated separately. Shrinkage in laundering is the decrease in the distance measured and is expressed as a percentage of the dimension before laundering.

General Washing Procedures

Choice of Family Washings:

Much of the testing of washers done by various commercial testing laboratories is by use of "stuffers" or large swatches of cotton material to simulate a specified weight load. To such loads standard soil testing materials are added. Such procedures have merit for certain tests but they do not approximate problems presented in a typical family washing. Actual family washings were used for testing in this survey and standard testing materials were added to loads of white clothes.

Washings were contributed weekly by 10 to 14 different families from nearby Columbus areas to introduce actual family washing problems. Men in these families were farmers, factory workers, mechanics, engineers, professors and high school teachers. There were from one to three children, predominantly boys, in most of the homes. Type and degree of soil varied considerably.

Sample Loads:

Only white and light colorfast items from family washings were used for the loads in which standard soil, whiteness retention, tensile strength, and shrinkage test swatches were added. A test load, including test swatches described in the foregoing tests, was exactly eight pounds for all washers. Each load included two sheets, two men's shirts, two pillow slips, two terry cloth towels, and other small items to give required weight. Generally, each family washing yielded only two or three test loads per week. The other items such as play and work clothes were washed separately and observed.

The Water Supply:

"Water has always played an important part in laundering, since it will dissolve or aid in the removal of many kinds of soil."[3] Water differs in localities depending upon the amount of dissolved mineral matter it contains. "Soft" water, which is comparatively free of these minerals, lathers freely when soap is added. Limestone, magnesium compounds, and other substances harden water as amounts increase. Soaps tend to combine with these minerals to form an insoluble precipitate known as soap curd. A sufficient amount of soap will "soften" the water and eventually lather. Packaged chemicals or zeolite systems installed in the water system of the home aid softening.

In the United States, hardness is usually expressed as one part of calcium carbonate in a million parts of water (p.p.m.). Fifty-five p.p.m. or less is considered soft water; 55 to 100 p.p.m., moderately soft; 100 to 200 p.p.m., moderately hard to hard; 200 to 500 p.p.m., hard to excessively hard.

Water was from the Columbus city supply where it was chemically softened at the filtration plant and maintained at an almost constant 68 p.p.m. hardness. Since this degree falls into the moderately soft water classification, no further softening was done prior to the addition of the detergent. Water conditions were more favorable than in many Ohio areas.

Hot water came directly from the Ohio State University heating plant and temperatures were fairly constant, between 135° and 140° F. No attempt was made to keep it at a given degree since it was desired to observe any influence temperature might have on soil removal. All other factors were kept as constant as possible.

All except one washer delivered the hot water for the washing cycle at the temperature of the supply. This one delivered it at a constant 130° F. regardless of higher temperatures at the source of the supply.

The Detergency:

At the time this study was started most of the manufacturers of automatic washers were beginning to recommend use of a synthetic detergent to eliminate possibilities of soap curd retention. Synthetic detergents do not react with minerals in the water as does soap. Manufacturers of cylinder and water-action type washers also recognized that a high suds buffered cleansing action in that type. The manufacturer of one of the cylinder washers used in this study recommended exclusive use of a low sudsing, synthetic detergent to eliminate the suds buffer.

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[3]Jessie E. Richardson, Home Laundering, Bulletin 432, Bozeman, Montana: Montana State College, Agricultural Experiment Station, December, 1945.

For all test loads, a low sudsing-built synthetic detergent containing a non-ionic type wetting agent, water softening compounds, and other moderately alkaline builders (10.2 pH) was used. Since the quantity of wash water in the washers varied from 9 to 17 gallons, the amount of detergent used was calculated to give a 0.3 percent solution for each test load. No bleaches, bluing, or other agents were used for test loads.

With the non-test loads, various detergents were used and quantities apportioned according to the degree of soil.

Method of Drying Employed:

All items from family wash baskets were dried in 220 volt automatic home type tumble dryers until completely dried (almost 40 minutes). All test swatches were taken from the loads before they were put in the dryers and were air dried on racks in the laboratory eliminating any wear factors beyond the washer.

Treatment of Individual Washings:

Two or more family washings were delivered to the laboratory daily. Each was washed separately except for combinations of work pants or special pieces such as scatter rugs and bath mats combined from two or more families when such grouping could expedite the process.

Each washing was carefully examined for spots, stains, or necessary pretreatment and its items were sorted into bins according to color and type of soil. All light colored items believed to be color fast were washed with white items in order to estimate combinations that might be made in the home.

An eight pound load, including test materials, was weighed and placed in the washer. Test loads included two sheets, pillowcases, towels, shirts and other white items. Each washer was set for a 10 minute wash period and the remainder of the cycle went according to that of the machine.

At the finish of the automatic cycle the clothes were examined for remaining soil, wrinkles, and condition in the machine. Loads from each machine were weighed several times at the end of the cycle to estimate water retention.

Following the drying period all items were folded and weighed. These figures were used in the calculations for a weight chart to be used by homemakers in estimating an eight pound load if scales were not available. (Table 11). For one year, records were kept of specific items and weights found in each laundry basket.

Fig. 11.—An 8 pound test load used in this study which included 2 sheets, 2 pillowslips, 2 bath towels, 2 men's shirts, and other small items.

RESULTS OF THE STUDY

Status of Cooperators:

During the period of this study, January 1, 1948, to June 1, 1949, over 20,000 pounds of soiled clothes were contributed by 32 different families. The family groups ranged from two to six members. Four families had no children, fourteen had two children, ten had three

children, four had two or three children with an additional one or two adults in the family.

The husband's occupations included:

Farmers	6
Garage Mechanics	3
Factory Workers	3
Electrical Engineers	2
High School Teachers	2
College Professors	8
Office Workers	7
Meat Cutters	1
Total	32

The children, predominantly boys, ranged in age from 1 to 14 years and provded a variety of garments and types of soil.

All of the women had previously been doing the washings at home. All but one family owned conventional wringer type electric washers. This home had an automatic washer.

Weight and number of articles were recorded for 300 separate washings. Distribution of the weights ranged from 10 to 44 pounds with from 25 to 128 articles, (Tables 2 and 3), with an average of 25.58 pounds and 66.3 items, respectively.

Weights and numbers of items varied greatly for the same families on different weeks. Occasional addition of such items as bath mats, robes, slip covers, draperies and blankets varied weights widely. Family habits appeared to have more influence on the number of items than did the number of members in the family. In some homes with two members there were more changes of shirts, undergarments, sheets, and towels than in larger families. In case of the latter, one sheet per week per bed and less changes of garments lowered the average number of items per person but increased the degree of soil.

Preconditioning of Clothes:

The first washer to be studied was washer 1. During the first days most loads were covered with heavy sticky lint deposits. These deposits

TABLE 2.—Distribution of the Weights of Three Hundred Family Washings

Pounds	Number of washings	Total weight
10 — 14.9	20	250.0
15 — 19.9	43	927.5
20 — 24.9	87	1,957.5
25 — 29.9	95	2,612.5
30 — 34.9	30	975.0
35 — 39.9	22	825.0
40 — 44.9	3	127.5
Total	300	7,675.0

Average 25.58 pounds per washing

TABLE 3.—Distribution of the Number of Items Found in Three Hundred Family Washings

Number of items	Number of washings	Total number of items
20 — 29	18	441
30 — 39	48	1,656
40 — 49	9	400
50 — 59	54	2,943
60 — 69	66	4,257
70 — 79	30	2,235
80 — 89	12	1,014
90 — 99	13	1,228
100 — 109	14	1,463
110 — 119	24	2,748
120 — 129	12	1,494
Total	300	19,879

Average 66.3 items per washing

had some characteristics of soap. In an attempt to combat this condition, subsequent loads were washed in clear hot water to which 1 cup of a non-precipitating water softener per 10 gallons of water had been added. In some loads the soap which had built up in the clothes over a period of time created enough suds to cause the machine to suds lock and occasionally to overflow. Washings where soap had been used in the home, at least six weeks were required to remove all retained soap because each week different items were added to the washings.

Even water of 68 p.p.m. (Columbus city supply) is sufficiently hard to create some soap curd formation in fabrics. Some of the contributors from the rural areas used water of from 425 to 680 p.p.m. making accumulation of soap and curd heavier.

All cotton and linens tend to lint with abrasion and it was believed that this lint adhered to the curd built up in the fabrics. When these items were washed with a synthetic detergent, it contained enough chemical softener to soften the soap formation releasing the lint. In the high spinning action during water extraction, this lint stuck to the fabrics in sticky streaks. Further trouble was eliminated by the preconditioning of each load with a stronger water softener solution before regular washing with the detergent.

Women encountering this difficulty were advised to try this preconditioning method and report the results. Only those who insisted upon the continued use of soaps reported failure. Use of synthetic detergents, eventually, if not immediately, remedied the trouble.

Early results were discarded and only after clothes were preconditioned were results recorded. With any of the washers, if the soap had

not been removed its presence would have influenced effectiveness of the detergent on soil samples.

Fugitive colors were seldom encountered. In case of doubt, an item was handwashed to check possibilities of color bleeding. Children's play corduroys (particularly red), blue jeans and occasional pairs of socks accounted for nearly all of the cases.

Typing of loads was given careful consideration because of certain manufacturers' recommendations that the machine be used as a clothes hamper and when a load had accumulated, it be washed. This recommendation is a drastic change from the traditional sequence of linens, bedding, towels, undergarments, light colored, dark colored, and extra-soiled items through a conventional washer and women reported that they were hesitant to wash unlike items together.

Test results from mixed loads were satisfactory as long as the degree of soil was similar. Including an extra greasy or heavily soiled item resulted in occasional grease ball deposits on the other items or finding that extra soiled items were not sufficiently clean. These conditions required a stronger detergency than was necessary for the entire load or additional treatment such as soaking or bleaching.

Cooperators were asked to comment upon the condition of their washings since test loads were put through the regular cycle of the washer without soaking, bleach, or bluing. (Frequently loads were rewashed and bleach added if there was extra soil or stain as was found in several washings.) Very few complaints were registered and in most cases the women said that their washings looked so much better than when done at home that few constructive suggestions were offered.

Results of the Standardized Tests

For convenience and to avoid use of commercial brand names washers used in this study will be called: Pulsator type—washer 1; cylinder types—washers 2A and 2B; and agitator types—3A and 3B; the conventional wringer type—the control washer.

Soil Removal From Standard Soil Materials:

The degree of soil removal from test materials made in the laboratory was lower than that used by certain commercial testing agencies. This was undoubtedly due to the fact that sheeting materials used have a finer thread count and are more tightly woven than the Indian Head used by the agencies. Since appearance of their sheets and pillow slips serve as a measure for good or poor washability, it was believed that this material was in keeping with home conditions. All other conditions being kept the same, removal of the soil from this material could be attributed to the washer.

Eight test samples were pinned, four on each, to two one-yard squares of white muslin. These squares were placed in the machines with test loads (Fig. 8). One sample from each square was removed and read on the Photovolt Meter after each washing. A fresh sample replaced the one removed. Thus 100 test samples were recorded for each washer. The three remaining samples on each square were read after every tenth washing.

Results of Single Washing Standard Soil Tests:

The variation of the percentage of soil removed from samples was greater within the individual machines than were the average between the machines. For example, the soil removed in washer 1 varied from 2 to 15 percent; 2A, 1 to 22 percent; 2B, 3 to 15 percent; 3A, 3 to 25 percent; and 3B, 1 to 15 percent.

Average soil removed by the five automatic washers is shown in Table 4.

These figures do not indicate a dramatic difference between the types of washers nor between individual brands. In washer 2A, where such a wide variation was observed, clothes frequently rolled into a ball and tumbled about in that fashion throughout the washing period. Soil samples that were rolled up in the ball lost less soil than those that tumbled freely. Items in the "ball" were less clean. Regardless of the care in loading, this condition could not be avoided.

Soil Removed and Water Temperatures:

Since water temperatures could not be held constant an attempt was made to wash at least 10 soil samples each in water varying at 5° F. intervals from 130° to 150° F. to ascertain if the temperature of the water was important (Table 5).

There was some indication of an increase in soil removal as temperature of the water increased. In water temperatures below 135° F. there was considerable spotting and streaking in the soil samples so that many were impossible to read and were discarded and other tests made. It was believed that the temperature was not high enough to affect the

TABLE 4.—Average Percent of Soil Removed from 100 Standard Soil Samples Washed in Each of the Three Types of Automatic Washers and the Control Washer

Type of washer	Machine	Average soil removed (percent)
Pulsator	1	9.72
Cylinder	2A	10.42
	2B	6.04
Agitator	3A	10.64
	3B	4.98
Conventional	Control	11.46

TABLE 5.—Percent of Soil Removed From Standard Soil Material in Water at Varying Temperatures in Three Types of Automatic Washers and the Control Washer

Type of washer	Temperature of wash water			
	130-134° F.	135-139° F.	140-144° F.	145-149° F.
	(percent soil removed)			
Pulsator 1	8.23	9.76	10.20	10.68
Cylinder 2A	8.50	9.37	11.57	10.10
Cylinder 2B	5.50	6.14	6.30	6.30
Agitator 3A	9.20	10.70	10.80	13.90
Agitator 3B[1]	4.98			
Conventonal control	10.10	10.50	12.40	13.00
Average for all machines	7.75	9.29	10.26	10.79

[1] 3B delivered water at 130° regardless of higher temperature of supply.

fat and oil substances of the soil. Grease balls or black insoluble spots appeared occasionally in the test loads washed at the lower temperatures but rarely in water at 140° F. When an additional amount of detergent was added in non-test loads at 130° F. there was no indication of grease balls.

Results of Soil Tests After Numerous Washings:

Three of the test soil samples on each swatch were washed 50 times and were read on the Photovolt Meter after every tenth washing. The loss of soil was greater between the first and tenth than between subsequent washing. (Table 6).

With all washers there was a gradual progressive loss with each successive tenth washing. Washer 1 (pulsator) removed the largest amount of soil, 58.9 percent, during fifty washings; the least, 39.2 percent, by washer 3B (agitator).

Results of Whiteness Retention Tests:

The gradual graying and yellowing of white clothes and the causes were constantly questioned by many women seeking information from

TABLE 6.—Percent of Soil Removed From Soil Test Samples During Continued Washing

Washer	Number of washings					
	1	10	20	30	40	50
	(Percent)					
1	9.7	40.3	48.2	51.7	55.5	58.9
2A	10.4	28.8	37.3	40.1	46.3	50.9
2B	6.0	22.4	30.4	36.2	39.3	43.2
3A	10.6	28.9	39.8	41.4	45.4	47.1
3B	4.9	18.9	28.4	35.4	37.6	39.2
Control	11.4	41.4	48.4	50.5	53.2	55.7

the researchers in this study. At meetings of the Home Laundry Equipment Manufacturers' Association, September 1949 and January 1950, home economists with manufacturers and educational representatives were in agreement that causes were due to:

1) Retained soil from inadequate washing and/or rinsing; or
2) Retained soap and soap curd built up in the fibers; yellowing particularly being caused by the application of heat in ironing when this condition existed; or
3) Yellowing might also be caused by the oxidation of soap retained in the fabric when exposed to direct sunshine; or
4) Continued ironing at too high temperatures.

The possibilities of soap and curd retention and oxidation were eliminated in this study through the use of a synthetic detergent and indoor line drying. The fabrics were not ironed. Consequently, since fabrics were new and unsoiled, the loss of whiteness was believed to be due to retention of soil finely suspended in the wash water that did not rinse out in the rinsing cycle.

The average of 12 reflectance readings each of the new desized white muslin sheeting swatches before washing was from 81.0 to 82.3. After washing with 50 test loads of soiled clothes the results are seen in Table 7.

Whiteness retention was highest in the pulsator washer (98.0 percent) with the control and cylinder type, 2B, at 97.0 and 96.5, respectively. To the naked eye the difference in whiteness of swatches from these machines could not be observed; however, when compared with washers where retention was 92.2 and 94.6 percent, the difference could be noted.

The amount of rinse water varied in the machines. Pulsator 1 had two deep rinses at approximately 10 gallons each. Two 15 gallon agitated deep rinses were used with the control machine. Both of the

TABLE 7.—Whiteness Retention of Muslin Sheeting Test Swatches During Fifty Washings With Soiled Clothes

Washer	Reflectance readings		Whiteness retention	Percentage loss
	Before washing	After 50 washings		
1	81.1	79.5	98.0	2.0
2A	81.0	74.7	92.2	7.8
2B	81.0	78.2	96.5	3.5
3A	81.1	77.3	95.3	4.7
3B	81.9	77.5	94.6	5.4
Control	81.4	79.0	97.0	3.0

TABLE 8.—Water Retention of the Eight Pound Test Loads in the Different Automatic Washers

Washer	Spinning speed (R P M.)	Average weight of 10 test loads after final rinse extraction (lbs.)	Pounds of water retained by 8 pounds of dry clothes	Whiteness retention (percent)
1	1130	11.9	3.9	98.0
2A	525	16.4	8.4	92.2
2B	500	15.9	7.9	96.5
3A	650	15.6	7.4	95.3
3B	1140	11.7	3.7	94.6
Control	(wringer)	15.9	7.1	97.0

agitator types of washers used one deep rinse of approximately 17 gallons with supplementary flush or spray rinses. The cylinder types used 16 to 18 gallons in sprays and 2 deep rinses.

The amount of water left in clothes seemed to have little relationship to whiteness retention. Table 8 shows the relative amounts of water retained by the eight pound test loads.

Theoretically, the larger amount of rinse water the greater dilution of soiled wash water retained after wash extraction.

Results of the Fabric Wear Tests.

The question concerning amount of wear on clothes by automatic washers was frequently asked by inquirers. Owners of automatics occasionally complained that their clothes seemed to show wear more quickly than with their conventional washers.

To determine if the wear factor was significantly different according to the type of washing, cotton tea toweling and sheeting swatches were used for testing. The swatches were washed through 50 complete cycles with soiled loads. This was believed equivalent to the maximum number of times that sheets and tea towels would be washed in the home during a two year period and wear would be due entirely to the machine since no other wear factor was present. All drying was done on a clothes rack thus eliminating the mechanical wear of a tumble dryer. Changes in breaking strength of the fabrics were based on ten tests.

As with other tests, there was wide variation in the results of wear in the different type washers and between washers of the same type. In tea toweling the changes in tensile strength of the filling thread varied from an increase in strength of +1.9 percent in washer 3B to a loss of 12.7 percent in a washer of the same type, 3A. Increase in strength may be attributed to shrinkage which actually increases strength.

In the warp direction thread there was a loss of from 6 percent in pulsator 1, to 24.3 percent in agitator 3A. (Table 9).

TABLE 9.—Changes in the Breaking Strength of Cotton Toweling and Sheeting Fabrics After 25 and 50 Washings in Automatic Washers

Materials	Washers					
	1	2A	2B	3A	3B	Control
	(Pounds)					
Cotton toweling						
Filling direction						
new	62.5	62.5	62.5	62.5	62.5	62.5
25th washing	61.3	62.7	58.8	58.2	67.0	56.7
50th washing	59.9	62.9	56.4	54.6	63.7	57.7
Percent change	— 4.2	+ 0.6	— 9.8	—12.7	+ 1.9	— 6.7
Warp direction						
new	65.6	65.6	65.6	65.6	65.6	65.6
25th washing	62.9	58.9	55.0	53.0	60.8	55.1
50th washing	61.7	59.0	52.6	49.0	60.8	55.1
Percent change	— 6.0	—10.1	—19.8	—24.3	— 7.3	—16.0
Cotton sheeting						
Filling direction						
new	39.0	39.0	39.0	39.0	39.0	39.0
25th washing	37.5	43.1	37.8	39.0	44.1	37.9
50th washing	36.8	44.3	38.8	41.6	41.3	34.5
Percent change	— 5.7	+13.6	— 0.5	+ 6.7	+ 5.9	—11.5
Warp direction						
new	56.4	56.4	56.4	56.4	56.4	56.4
25th washing	54.4	56.1	55.5	45.6	55.9	53.3
50th washing	52.6	55.5	54.8	49.5	54.1	49.3
Percent change	— 6.8	— 1.6	— 2.8	—12.2	— 4.1	—12.6

Changes in tensile strength of the muslin sheeting also varied considerably. Variation of the filling direction thread was from an increase of 13.6 percent in cylinder type 2A to a loss of 5.9 percent in agitator 3B. Greatest loss was in the control washer of 11.5 percent. There was a loss in the warp direction of from 1.6 percent in the cylinder type 2A to 12.2 percent in agitator 3A.

The threads in the toweling were more loosely woven and irregular in size and count than in the sheeting. It can be expected that there would be wide variation in breaking strength. The original unwashed samples of toweling varied as much as 10 pounds in filling and 9 pounds in warp. Strength of the sheeting varied less than two pounds in either filling or warp.

The washers with mechanical action—1, 3A, 3B, and control—showed greater wear on the fabrics than the cylinder types, 2A and 2B.

Results of Shrinkage Tests:

Three cotton tea toweling swatches were used with each washer and washed 50 times with soiled clothes to check washing action influence on shrinkage. Results as shown in Table 10 indicate that the major shrinkage occurred in the first washing. The range of shrinkage after the first

TABLE 10.—Shrinkage of Cotton Tea Toweling After the First and Fiftieth Washings in Three Types of Automatic Washers

Washer	After first washing	After fifty washings
	(Percent)	
1	7.77	8.57
2A	7.23	8.66
2B	6.13	8.63
3A	5.66	8.60
3B	7.53	9.03
Control	6.66	7.19

washing was from 5.66 to 7.77 percent; a range of only 2 percent which might easily have been in the degree of error of measurement. After 50 washings the variation was from 7.19 to 9.03 percent, an average increase of only 2 percent above the first washing and a variation between the machines of only about 2 percent. Thus it appears that this particular test shows that the type of washer had no influence upon the degree of shrinkage.

Selection of Suitable Loads:

Besides the test loads containing the swatch materials previously described, 50 or more loads were washed in each of the washers studied. Various combinations of all large or all small items or mixed items per load were tried. The combination of small items was satisfactory in that they moved freely in all types. The combination of all large items such as sheets was not satisfactory. In the agitator-type washers the sheets did not move freely and tended to billow around the agitators. Since they did not turn over and move freely the agitator mechanism seemed to drag on the items in the same spot giving more vigorous motion and agitation in the mechanism area.

For practical reasons the best loads for all types of washers included a combination of large and small items. For example, a typical load included:

2 sheets	3 lbs. 4 oz.
2 pillowslips	9 oz.
2 bath towels	1 lb.
2 men's dress shirts	1 lb.
2 luncheon cloths	1 lb. 2 oz.
Tea towels and other small items	1 lb. 1 oz.
Total	8 lbs.

Most washings provided two such loads, a third load of items such as dresses and undergarments, and a fourth load (usually less than eight pounds) of play and work clothes and socks which had to be washed separately from white or items with less soil.

Suitable Load Weights:

Manufacturers of the cylinder and agitator-type washers rated the load capacity as nine pounds; the pulsator washer as eight pounds. Observations of the machines in action made investigators believe that a nine pound rating was too high. In agitator 3B a nine pound load gave excessive billowing and the "billows" were seldom pulled under the water; the turn-over of items was so slow that the agitator mechanism seemed to play continuously on the same items. In agitator washer 3A there was less billowing than in 3B but slow turn-over of clothes. When only seven and a half or eight pounds of clothes were washed in either machine the items generally moved about more freely and seldom billowed.

Nine pounds in the cylinder-type usually had to be crowded and forced tightly into the tub. Such a load reduced the space for the fall of items. Washing action in this type depends greatly upon the fall and turning of the clothes and action is reduced under heavier loads.

During the progress of this study over 75 telephone calls were received from women complaining that their cylinder-type washers would not remove soil. After eliminating other possible reasons for poor soil removal such as type of detergent or hot water it was suggested that the size of the load be reduced. If this did not solve the trouble they were to report. Only 3 of the 75 persons reported continued trouble. Ten self-service laundry operators reported that their greatest washability problems with cylinder-type washers were due to overloading the machines.

It would be advisable for all homemakers to use a scale until they establish the contents of an eight pound load. Table 11 gives the average weights of individual items weighed during 100 washings in this study which may also be used as a guide if scales are not accessible.

Loading Problems With the Washers:

The pulsator and agitator-type washers were loaded from the top; cylinder washers from the side (Figures 2, 3 and 4). The design of the openings to the tubs influenced the ease in loading and removing clothes; pulsator 1 and agitator 3A had openings of the same diameter as the tub making loading easier than with 3B where the opening was square and smaller. The topcovers of 3A and 3B were detached which was an inconvenience since they always had to be placed elsewhere during loading and removing the loads. Consequently, they were usually left off during use. Washer 1 had a hinged lid which could be easily raised and closed.

TABLE 11.—Average Weight of the Main Household Items and Clothes as Based Upon One Hundred Family Washings

Item	Number items washed	Total weight (pounds)	Average weight per item
Sheets—double	240	397.0	1 lb., 10 oz.
single	60	77.0	1 lb., 4.5 oz.
crib	15	10.0	10 oz.
Bed spreads	10	31.6	3 lb., 2.5 oz.
Pillowslips	365	105.0	4.6 oz.
Tea towels	530	90.0	2.7 oz.
Dish clothes	10	1.0	1.6 oz.
Terry towels—large	400	197.5	7.8 oz.
small	140	41.3	4.6 oz.
Huck towels	15	2.5	2.5 oz.
Wash clothes	460	35.5	1.2 oz.
Bath mats	5	5.0	1 lb.
Scarves	30	5.3	2.7 oz.
Table clothes	15	20.0	1 lb., 5 oz.
Luncheon clothes	40	24.4	9.8 oz.
Napkins—large	50	5.0	1.6 oz.
small	30	2.4	1.2 oz.
Women's dresses	135	87.5	10.4 oz.
blouses	85	30.0	5.6 oz.
skirts	5	3.1	10 oz.
slips	90	27.5	4.9 oz.
panties	95	22.8	3.8 oz.
aprons	80	18.5	3.7 oz.
gowns	60	28.1	7.5 oz.
pajamas	10	11.9	1 lb., 3 oz.
housecoats	10	13.8	1 lb., 6 oz.
Men's dress shirts	290	143.7	8 oz.
work shirts	100	78.1	12.5 oz.
wool shirts	15	16.9	1 lb., 2 oz.
shorts	200	37.5	3 oz.
vests	196	34.3	2.8 oz.
pants	55	74.0	1 lb., 5.5 oz.
overalls	25	26.6	1 lb., 1 oz.
jackets	10	15.0	1 lb., 8 oz.
sweat shirts	20	13.8	11 oz.
jerseys	30	8.4	4.5 oz.
socks	210	19.4	1.5 oz.
handkerchiefs	350	10.9	.5 oz.
pajamas	60	75.0	1 lb., 4 oz.

Loading cylinder 2A required considerable bending and stooping but in removal the load could be easily "scooped" into a basket or container. The tub opening of 2B was also a front fill but on an angle which made loading easier and required less bending. Both cylinder-type washers rotated for a short period after the final spin which loosened the clothes from the side wall of the tub and tumbled them enough to "fluff" or remove a large portion of the wrinkles. In both of the agitator and pulsator types the clothes remained tightly packed against the sides of the tub following the final water extraction spin.

Special Washing Problems:

Items such as pillows, quilts, slip covers, shag rugs, heavy bed spreads, robes, draperies, and blankets pose special problems in washing. In general, and with the exception of wool blankets, these items were more easily handled in the cylinder-type washers.

Shag rugs and feather pillows were particularly difficult to wash in the agitator and pulsator types. Because of size and shape they caused unbalanced loads in spinning and pillows in particular were difficult to keep under the water even when they were vented to allow air to escape. The heavy spread and quilts tumbled more freely than in the agitator and pulsator types. The main advantages of washers 1 and 3B having high speed spinning action was that so much more water was removed in the final rinse extraction the items were more easily dried. The control washer was at a disadvantage with these items since the wringer could not handle them and hand squeezing or wringing was necessary.

Wool blankets and wool clothing offer different and specific problems. In a supplementary study, Martha A. Plonk, found that shrinkage of wool blankets was due principally to agitation and mechanical action of the blankets in water; temperature of the water had little or no effect.[4] When blankets of the same type (four pound wool) were given two and four minute washing periods the results were as follows:

Washer	1 washing		5 washings	
	2 min.	4 min.	2 min.	4 min.
Pulsator	5.4	5.0	6.3	12.1
Cylinder	7.9	8.3	15.0	13.3
Agitator	4.2	6.3	7.5	13.3
Control	4.2	6.3	7.9	14.6

Following Miss Plonk's study further washing of blankets was done in an attempt to further reduce shrinkage. Blankets, soaked in the washer 15 to 20 minutes in a warm synthetic detergent water, readily lost the soil without any agitation or mechanical action. Following the soaking period water was spun off and blankets were soaked in two different clear warm rinse waters for about five minutes and then spun. Measurements taken on 20 new, all wool blankets showed no more than 2 percent shrinkage. When these same blankets were blocked and brushed with a small wire bristle brush they were returned to their original length and were, in some cases, slightly longer.

As a result of these experiments it was concluded that wool blankets can be washed successfully in an automatic washer providing (1) the washer does not agitate or tumble while filling or, if it does, the lid or

[4]Martha Amanda Plonk, "A Study of Blanket Laundering in Automatic Washers," unpublished Master's Thesis: Columbus, Ohio: The Ohio State University, 1949.

door can be opened and the blanket added after the tub is filled, (2) the washer control dial is flexible allowing manual operation to change the cycle at any point. At least three of the automatic washers now on the market do not have flexible dial controls which can be manually operated or the door cannot be opened after the tub is filled.

Following these experiments several washer manufacturers adapted this method of washing blankets and have issued specific directions for their particular washers.

The Use of Washing Aids in the Washers:

No washing aids, such as bleach, bluing, and ammonia were used with the loads containing the test swatches. Frequently, however, it was necessary to rewash and treat certain items such as towels and children's and men's white undergarments. Extremely soiled white items were not put into the test loads. When the appearance of the clothes warranted, a chlorine bleach was added in the proportion of 1 cup to 10 gallons of the hot wash water. Since a synthetic detergent was used there was no problem of curd formation with use of bleach in wash water. This treatment generally whitened the clothes satisfactorily.

According to a General Electric consumer research report, 98 percent of the women contacted used bleach in their wash regularly.[5] From the experience and results in this study it is believed necessary to bleach only when regular washing practices fail to remove tenacious stains. The use of new permanent finishes to rayons and cottons is causing problems in the use of chlorine bleaches. Bleaches frequently cause the fabrics to yellow and streak.

When certain family washings appeared extra soiled week after week cooperators were asked, if possible, to change household linens and clothing more frequently. This practice increased the size of washings to some extent but pretreating and bleaching were reduced and the final appearance was improved. More frequent moderate washing is believed less harmful on fabrics and garments than less frequent with drastic washing and/or bleaching methods to remove soil and provide good results.

Extremely dirty and greasy work pants, overalls, and frequently the undergarments worn with them were washed with additional detergent and the addition of household ammonia which raised the alkalinity of the washing solution to cut the grease.

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[5]Fourth National Home Laundry Conference Report, Chicago, Illinois: January 10-11, 1950. p. 56.

Care and Service Needed with the Automatic Washers:

Rumors of and experiences reported regarding frequent and expensive servicing of automatic washers brought various questions. The greater the number of automatic features on any appliance the greater the possibilities for need of service; however, it need not be true.

Use and wear of three of the washers used in this study was equivalent to that of ten to twelve years in the home. All washers were new when the study was started and during the time only the following service calls were necessary:

Machine	Service calls	Trouble
Pulsator	2	Broken drain hose. Timer out of adjustment
Cylinder 2A	2	Pulley belt broken. Detergent dispenser clogged. Spin cycle out of adjustment
Cylinder 2B	0	(Used for shorter time than other washers)
Agitator 3A	1	Control dial out of adjustment
Agitator 3B	2	Defective agitator which caused tearing. Replaced on second call
Control	2	Motor dropped from mounting. Broken wringer

Occasional fuses were blown in overloading trials without damage to the machines. Wiring and voltage factors were favorable which doubtlessly contributed to this good performance.

Little cleaning was required for any machine. Use of a synthetic detergent left no lime or soap scum deposits in tubs or drains. The mesh detergent dispenser in the pulsator washer had to be removed occasionally and brushed to remove accumulated lint. The lint trap of cylinder 2A had to be removed daily and cleaned; otherwise, it would clog and prevent the tub from emptying. Likewise, the strainer over the drain in agitator 3B and in the control washer had to be cleaned. The agitating mechanisms in the agitator washers were removed from the post for cleaning.

No deterioration of tubs or agitator mechanisms was noted at any time. In general, it can be said that a minimum of care and service was necessary for any of the washers.

Water Consumpton of the Various Washers:

One of the most frequent questions from prospective buyers concerned water consumption. Cost of water and heating were of greatest concern but in rural areas individual home supply was sometimes limited and water pressures were uncertain.

The amount of water used by the different washers varied greatly. The requirements were as follows:

Washer	Total gallon water per load	Hot water, gallons per load	Minimum pressure required (pounds)
1	30	18	25
2A	32.4*	17*	20
2B	26	16	20
3A	37.5†	20	15
3B	52*	35*	20
Control	51	30	*

*Including soak cycle.
†Suds return allows for reuse of wash or rinse water if desired.

In this particular study there seemed to be no direct relationship between the varying quantity of water used and the soil removed but there was slightly better whiteness retention in washers having two deep rinses (exception 2A) and good water extraction.

A difference of from 26 to 52 gallons per load is an item for consideration in case of a limited water supply. The automatic washer cannot be recommended for homes with an extremely limited supply or with low water pressure. A home having an adequate water supply and a good pressure system will probably experience little or no difficulty. In the case of low pressure gravity water systems, washers with a time control fill will fill slowly or insufficiently and with one type of washer performance will be retarded. With the conventional washer water can be reused or the amount reduced in times of shortages but at present only two automatic washers on the market, incorporate this feature. In homes where the hot water supply is limited these machines have an advantage.

The question "Won't an automatic washer use lots more water than my 'old' washer?" can be answered only in terms of the automatic washer being considered, and the woman's past practices with her conventional washer. Few women questioned had any idea as to the exact amount used with the conventional washer and/or rinse tubs. Assuming that the conventional washer and the 2 rinse tubs each held 15 gallons each, and all of the loads of clothes were put through the same waters approximately 45 to 50 gallons would be used. If the woman changed the water at least once, 90 to 100 gallons would be needed. Again, assuming the size of the washing would provide 4 loads in an automatic washer, the consumption would be: Washer 1, 120 gal.; Washer 2A, approximately 100 gal. without soak cycle; 2B, 104 gal.; 3A, 150 gal. without reuse of suds water; 3B, 208 gallons.

While the water consumption may or may not be appreciably greater, depending upon practices, consumption of detergent will be somewhat increased. It may be expected, however, that the results will be better when clothes are always washed in clean, fresh water.

Hot Water Requirements for Automatic Washers:

The requirements for hot water directly from the hot water heater (except washer 3B which limits temperature to 130°) ranged from 16 to 35 gallons depending upon the capacity. Since the rinse waters were tempered to 100° F. the amount would be slightly higher in extremely cold weather and somewhat lower in warm weather. In order to wash the average of four loads in sequence, 72 to 140 gallons of maximum temperature (135° to 140°) was needed, again depending upon the washer. (See Table 1).

Heating tanks of the 30 gallon capacity were predominant. With this limited supply it would not be possible to wash more than 2 loads in sequence with washers requiring 16 to 20 gallons of hot water or more than one load with those of higher capacity. It would be necessary for the user to wait for the supply to reheat or change laundering practices, washing one or two loads on two or three different days during the week.

The practice of washing more frequently has advantages in that soiled clothes do not accumulate for a longer period of time. Stains and soils do not become as tenacious, and the mildew is less frequent. With an automatic machine, loads can be washed while other tasks are being performed. In combination with an automatic dryer there would be little need for an accumulation or storage of soiled clothes.

If it is necessary to complete the washing and drying in one day, a larger water heater will be necessary to use an automatic washer, preferably one of 50 to 75 gallon capacity.

Advantages and Disadvantages of the Different Types of Automatic Washers:

The perfect all-advantage automatic washer is not yet designed. Each washer had advantages and disadvantages, good features and objectionable features.

Advantages and desirable features of the washers used, particularly liked by the investigators, were:

1. High speed centrifugal water extraction. Less weight to handle in carrying and hanging clothes. Less time required for drying both on line and in automatic dryer (reduced cost of operation). Numerous rayon and light cotton items could be ironed directly from the washer without drying.
2. Clog proof drains and traps. Eliminated frequent cleaning of traps which, when clogged, prevented water from draining.
3. Top loading for comfort and elimination of bending and stooping.
4. The "fluffing" process provided by the cylinder type which loosened items and eased twisting. The process eliminated set wrinkles if the clothes were not immediately removed from the washer.
5. Flexible dial controls which would respond to start or shut-off at any position in cycle by merely pushing or pulling dial. All washers used in this study had flexible dial control so that the cycle could be changed at any time. Two other brands now on the market have restricted dials which often prove to be a disadvantage when washing certain types of loads. Dials that could be controlled by grasp rather than thumb operation were more easily operated.
6. Well balanced tubs which did not easily trip switch and stop operation or produce excessive noise and wear on machine if the load was out of balance.
7. All porcelain finish—ease in cleaning and eliminated rusting. No chippinb was experienced in two years wear.
8. Hinged cover which eliminated having to locate resting place for lid.
9. Large top and tub opening to make for convenience in loading and removing clothes.
10. Maximum temperature hot water consumption for wash cycle.
11. Compact dimensions requiring minimum space and flush-to-wall installation for ease in cleaning.

For specific features of washers see Table 12 on page 42.

TABLE 12.—Advantages and Disadvantages of the Five Automatic Washers Used in the Study*

Machine	Special advantages	Disadvantages
Pulsator 1	Simple operation of easily accessible controls. High water extraction, automatic cut-off controls for over-loads and unbalanced loads, access to tub during cycle, clog-proof pump. All porcelain finish. Could be operated manually on partial fill if desired. Immediate dial control by pulling dial. Hinged tub cover.	Time control fill which requires sufficient water pressure to assure adequate fill. Excessive twisting of clothes.* Tub easily thrown out of balance.*
Cylinder 2A	Automatic detergent dispenser, soak cycle.	Door could not be opened during operation. Drain clogged easily preventing emptying of water. "Balling" of clothes. Low water extraction. Dial required complete turn to shut off.
Cylinder 2B	Access to tub during cycle. Front opening slanted for ease in loading. Three level water fills for small, medium, and maximum loads. Non-clog drain. Immediate dial control by pushing dial. Weighing device on door to prevent over loading.	Low water extraction.
Agitator 3A	Ease in top loading. Tub filled with water before machine started to operate on automatic cycle. Could be operated manually for partial fill if desired. Suds return for re-use if desired. Non-clog drain. Immediate dial control. Well balanced tub. Quiet operation.	Wash water drained down over clothes before spinning leaving suds deposited on clothes. Low water extraction. Detached tub cover.
Agitator 3B	High water extraction. Flush rinses. Reversible dial control. Retention of final rinse to be used for soaking or wash of items requiring low water temperatures.	No shut-off device for unbalanced loads. Controlled low water temperature. Too large water capacity. Necessary to remove tub for cleaning lint trap.* Full tub fill required before machine would operate. Noisy in spinning cycle. Detached tub cover.

*Features corrected or eliminated in 1950 models.